Lesson 3F—Narrative: How Do Archaeologists Analyze and Date Ancient Technology?

Several scientific methods of analysis and dating assist archaeologists in their study of ancient technology.

Archaeologists study artifacts to learn how they were made and used. Knowing the age of an artifact is also of extreme importance. When archaeologists know when different artifacts were created, they can compile a **chronology** of past events. A chronology is a sequence, or timeline, showing changes over time in lifeways, including changes in tool technology, subsistence strategies, dwellings, clothing, and expression through art. The past cannot be reconstructed without a sequential knowledge of these events.

Archaeologists often study the shape and size of stone artifacts. In Montana, stone projectile point size and style changed over time. Since some types of points and other tools were only made at certain times, these tools help archaeologists determine how old a site is. Archaeologists also study the **chemical composition**, or make-up, of stone material. Some stone, like obsidian, can be traced to its source by studying its chemical composition. Information about prehistoric travel and trade can be obtained in this way. Archaeologists also research stone quarrying and tool manufacture methods. By studying the tool and the stone waste flakes, or unusable pieces produced when making the tool, archaeologists can reconstruct specific **stone tool manufacture** techniques. By studying the different kinds of waste flakes found, archaeologists may be able to determine the type of tool knapped at a site even if they don't find the artifact itself!

Archaeologists also gather information through **microscopic** study of stone tools and implements. The edges of scrapers and butchering tools sometimes show wear patterns and **blood residue** from butchered animals. These clues identify what foods were consumed at the site. Very much like detective work, this is an exciting area of archaeological research.

The ages of artifacts made of bone, charcoal, antler, or wood can be determined by **radiocarbon dating**. Pictographs can also be radiocarbon dated if prehistoric artists used organic materials to bind the paint. In 1949, Willard Libby discovered radiocarbon dating. The method revolutionized archaeology because it told archaeologists how old—in years before the present—their sites were. Dr. Libby won the Nobel Prize for this invention. The basic principle behind radiocarbon dating is simple. All organic material contains some minute **radioactive elements** that break down and release energy at a constant rate, or **half-life.** In radiocarbon dating, scientists measure the amount of release, or decay, as elements change from radioactive **carbon-14** to non-radioactive, or stable, nitrogen-14. In an organic object like a tree or the skeleton of an animal, the ratio of radioactive elements stays the same until the living material dies and no new elements are added. Scientists compare the amount of both elements remaining in archaeological bones or charcoal from a campfire to determine how much radioactive decay has occurred and thus the number of years that have passed since the death of the living object. Radiocarbon dating is accurate in determining the age of organic artifacts as old as forty thousand years! Many hundreds of radiocarbon dates have been obtained from archaeological sites across Montana. They range from almost twelve thousand to one hundred years ago. In radiocarbon dating, "B.P." is sometimes used to indicate how old something is "Before the Present."

Another method of dating wood artifacts is **dendrochronology**, or tree ring dating. This method relies on the pattern of annual, or yearly, growth in tree rings. A tree cut at a known date is compared with progressively older tree rings. This process establishes a "tree growth" chronology over many centuries. The tree rings in wood found in an archaeological site can be compared to this chronology. By matching the sequence of rings and counting back in time, the age of the wood can be determined along with the age of the site. But dendrochronolgy is limited to certain areas where the proper tree species are available and tree segments have been preserved. For these reasons, tree ring dating is not widely used in Montana. One exception is using tree rings to date cambium-peeled "scarred" trees in western Montana; the cambium was used as food.

For Montana archaeological sites, another useful dating method is **obsidian hydration dating**. Geologists Irving Friedman and Robert Smith discovered this method of dating in 1948. Obsidian artifacts absorb water, or hydrate, at a specific rate. Freshly knapped obsidian begins to absorb water on its newly exposed surfaces. Water penetrates deeper into the surface over time. By measuring the thickness of the **hydration rind**, archaeologists can estimate the relative age of two artifacts. The obsidian artifact with the thicker hydration line is older. If a hydration rate for the area has been established, the artifact can also be given a precise date. One problem with this method is that rates of hydration are difficult to determine and are not uniform from one location to another.

Archaeologists use other methods to date certain kinds of artifacts. The age of bones can be determined by **amino acid** dating. This process measures the amount of decay of protein molecules within bone. Rock art can be dated by **superimpositioning** and by **figure content cross dating.** Superimpositioning assumes that if one design is painted on top of another, the underlying design was painted first and is oldest, just like the law of stratigraphy. Figure content cross dating compares rock art designs within a given area, and those that are the same or similar are assumed to be made during the same period of time. This same principle is used to say that two projectile points that look alike are probably similar in age. Finally, pottery and even burnt stone can be dated by **thermoluminescence**. This method measures the light energy a previously baked artifact gives off when it is heated again to a very high temperature. Older objects give off more light energy.

These are only a few of the specialized techniques used by archaeologists to study prehistoric sites and artifacts. Archaeologists also depend on methods and theories from many different scientific fields. **Geologists, botanists, zoologists, geographers** and many other specialists make up an **archaeological research team**. Every year, these scientists develop new technologies that help archaeologists. Without the help of these people, and many sophisticated techniques, we would know much less about Montana's ancient past.

Lesson 3F—Vocabulary: How Do Archaeologists Analyze Information about Technology?

amino acid dating

archaeological research team

blood residue

botanists

carbon-14

chemical composition

chronology

dendrochronology

figure content cross dating

geographers

geologists

half-life

hydration rind

microscopic

obsidian hydration dating

radioactive elements

Lesson 3F—Vocabulary: How Do Archaeologists Analyze Information about Technology? (continued)

radiocarbon dating ____________________

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stone tool manufacture ____________________

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superimpositioning ____________________

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thermoluminescence ____________________

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zoologists ____________________

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LESSON 3F—ARCH ACTIVITY: DETERMINING THE AGE OF ARTIFACTS

Grades: 6–8
Time: 30 minutes
Content Area: science and math
Who: individual and whole class

Materials:
- **calculator**
- **paper and pencils**
- **Arch Journal**

OBJECTIVE AND OUTCOME

•Students will learn how archaeologists use obsidian artifacts to date sites.

•Students will compute the age of obsidian artifacts based on the hydration formula and the thickness (in microns) of the hydration rinds developed on these artifacts.

ACTIVITY

1. Explain that the following hydration formula has been determined for the Government Mountain–Sitgreaves obsidian flow in the American Southwest, where Y is the computed date of an obsidian artifact based on x, its hydration rind measurement in microns.

Hydration Rate Formula

$Y = 43.58 + 158.16(x^2 - x)$

2. Using the formula, have each student compute the age of the artifacts listed below from two archaeological sites (Site 1 and Site 2).

Example:

If an artifact has a hydration rind of 1.8 microns, then:

Y = 43.58 + 158.16 (1.8 squared -1.8)
Y = 43.58 + 158.16 (3.24 - 1.8)
Y = 43.58 + 158.16 (1.44)
Y = 43.58 + 227.75
Y = 271 years B.P. (before present)
The artifact is 271 years old.

Site

* small obsidian arrow point with a hydration rind of 1.6
* obsidian knife with hydration rind of 1.9
* obsidian scraper with a hydration rind of 1.95

Site 2:

* obsidian arrow point with a hydration rind of 1.5
* obsidian flake with a hydration rind of 1.6
* obsidian knife with a hydration rind of 4.6
* obsidian spear point with a hydration rind of 8.3

3. Discuss with the whole class the differences between the two sites based on the age of the artifacts found there.

4. What could those differences mean? Why might people return to Site 2 over many thousands of years?

EXTENSIONS

6–8:

• Research vocabulary.

See: Lesson 3F—Vocabulary

• Give students the age of four Government Mountain–Sitgreaves obsidian artifacts that are 213; 516; 1,244; and 3,648 years old. Challenge them to compute the thickness of the hydration rind for each artifact using the hydration rate formula.

• Challenge students to research other dating methods in archaeology that rely on mathematical formulas. Have them list and describe these other formulas in their Arch Journals.

Answers

Site 1:

The arrow point is 195 years old.
The knife is 314 years old.
The scraper is 337 years old.

Site 2:

The arrow point is 162 years old.
The flake is 195 years old.
The knife is 2,663 years old.
The spear point is 9,626 years old.

Extension Exercise:

The hydration rinds are:
1.65 microns
2.3 microns
5.3 microns
3.3 microns